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Environment, Safety, and Health

Volume II

Part 20: Ionizing Radiation, Non-Ionizing Radiation

Document 20.1 Occupational Radiation Protection

Recommended for approval by the ES&H Working Group

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Occupational Radiation Protection

1.0 Introduction

The Department of Energy's (DOE's) rule on *Occupational Radiation Protection* (10 CFR 835, also referred to as "the Rule") requires LLNL to have a formally approved document, *LLNL Radiation Protection Program (RPP)*. The RPP is a legally binding document between LLNL and DOE and includes the text of 10 CFR 835 and LLNL's implementation methodology. The Rule, LLNL's implementation methodology, and cross-references to the *Environment, Safety, and Health (ES&H) Manual* are presented in Document 20.5, "Occupational Radiation Protection: Implementation of 10 CFR 835." The text of the Rule, in combination with LLNL's implementation methodology, prevails in case of ambiguity with other LLNL documents.

The Rule contains all the elements of a comprehensive radiation protection program (i.e., management and administrative requirements; radiation dose limits; and requirements for monitoring individuals and areas, posting and labeling, recordkeeping, radioactive material control, training, and emergency response). The Rule applies to LLNL management, supervisors, and individuals who handle radioactive materials, operate radiation-generating devices (RGDs), or may be exposed to ionizing radiation because of their work. No one may act (or cause others to act) in a manner inconsistent with the Rule or any program, plan, schedule, or other process established by the Rule. However, nothing in the Rule shall be construed as limiting actions that may be necessary to protect health and safety.

This document delineates LLNL's Radiation Safety Program and contains the requirements and best management practices that pertain to routine radiological operations. Provisions for nonroutine operations are contained in Document 20.5 and Document 22.6, "Exposure to Radiation in an Emergency," in the *ES&H Manual*. Requirements and controls specific to radioactive materials and RGDs are contained in Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials," and Document 20.3, "LLNL Radiological Safety Program for Radiation-Generating Devices," in the *ES&H Manual*. Requirements are presented as "shall" statements, and best management practices are presented as "should" statements. Table 1 identifies the documents that address various elements of LLNL's Radiation Safety Program. Appendix A defines "shall," "should," and other terms used in this document. Radiological policies and requirements for Nevada Test Site operations are contained in Volume VI of the *ES&H Manual*.

Table 1. ES&H Manual documents in Volume II that implement LLNL's Radiation Safety Program.

Elements pertaining to:	Are contained in:	ES&H Manual cross-reference
Management of the radiological protection program or Both radioactive materials and radiation-generating devices (RGDs)	<ul style="list-style-type: none"> • "Occupational Radiation Protection" • "LLNL Occupational Radiation Protection ALARA Program" • "Occupational Radiation Protection: Implementation of 10 CFR 835" • "Exposure to Radiation in an Emergency" 	Document 20.1 Document 20.4 Document 20.5 Document 22.6
Handling, storage, or transportation of radioactive materials (including radioactively contaminated items)	<ul style="list-style-type: none"> • "LLNL Radiological Safety Program for Radioactive Materials" 	Document 20.2
Operation of RGDs	<ul style="list-style-type: none"> • "LLNL Radiological Safety Program for Radiation-Generating Devices" 	Document 20.3

LLNL management, supervisors, and workers shall comply with the requirements in this document and its associated documents when managing or conducting radiological work either onsite or offsite. Failure to do so can result in civil and criminal enforcement actions. Work conducted at another site or location where LLNL does not have overall management responsibility shall be conducted in accordance with the other site's established regulations and policies for handling radioactive materials and operating RGDs. Usually, the site requirements are specified in the RPP, a Nuclear Regulatory Commission (NRC) license, or an NRC-agreement state license.

This document and its associated documents do not apply to

- Background radiation.
- Consumer products emitting nominal amounts of radiation.
- Activities conducted under the Nuclear Explosives and Weapons Surety Program (relating to the prevention of accidental or unauthorized nuclear detonations).
- Offsite radioactive material transportation (including between the Livermore Site and Site 300).
- Medical and dental exposures.
- Activities, items, or articles regulated by the NRC or other federal agencies.

2.0 Hazards Associated with Radiological Operations

Radiological operations could result in internal or external dose to workers; contamination of workers, work areas, equipment, or facility systems; or release of radioactive material to the environment. The risk from occupational radiation dose depends on the amount of radiation dose received, the time over which the dose is received, and the parts of the body exposed. Acute exposure occurs when a radiation dose is delivered in a short period of time—from seconds to days. Chronic exposure occurs when a radiation dose is spread out over an extended period of time—usually months to years. Normally, a chronic dose is less harmful than an acute dose because the body has an opportunity to repair cellular damage. There is substantial scientific evidence that humans exposed to acute, high doses of radiation may exhibit adverse health effects (acute radiation syndrome or an increased risk of cancer). Below an acute dose of 10 rem, health effects are either too small to be observed or nonexistent.

Contamination of workers, areas, or equipment does not necessarily result in a measurable or recordable radiation dose, but does significantly increase the cost of conducting business. Implementation of this document and its associated documents ensures general employees, visitors, and LLNL are adequately protected and that LLNL achieves compliance with the Rule.

3.0 Administrative Elements

3.1 Internal Audits

LLNL shall conduct internal audits of the Radiation Safety Program to identify its strengths and weaknesses, areas of vulnerability, and noncompliance. The audits shall be conducted no less frequently than every 36 months and shall include examination of the radiological protection program content and implementation. LLNL's internal audit process is managed by the Hazards Control Department's Radiation Safety Program Leader (RSPL) and is described in Appendix B.

3.2 The ALARA Approach

As low as reasonably achievable (ALARA) is an approach to radiation protection to manage and control individual and collective dose to employees and visitors to levels that are as low as reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit, but a process for maintaining doses as far below the applicable limits as is reasonably achievable. The ALARA philosophy is based on the supposition that radiation dose increases one's risk of cancer—the smaller the dose, the smaller the risk. Although this premise has not

been proven at low doses of radiation (i.e., acute whole-body doses less than 10 rem), the Rule requires formal plans and measures for applying the ALARA process to occupational radiation exposure.

The Laboratory's policy is to plan and conduct its radiological activities in a manner that protects the health and safety of all its employees, contractors, the general public, and the environment. In achieving this policy, LLNL shall ensure that efforts are taken to reduce radiological exposures and releases to as low as reasonably achievable, taking into account social, technical, economic, practical, and public policy considerations. LLNL's ALARA Program is described in Document 20.4, "LLNL Occupational Radiation Protection ALARA Program," in the *ES&H Manual*.

3.3 Design Criteria

During routine operations, a combination of physical design features, workplace monitoring, and administrative controls shall be implemented to ensure that any anticipated occupational dose does not exceed the allowable dose limits shown in Table 2. Document 20.4 contains general design criteria and describes LLNL's ALARA process. In addition, Document 20.2 contains design criteria that apply exclusively to radioactive materials; Document 20.3 contains design criteria that apply exclusively to RGDs.

Table 2. Annual dose limits for various categories of people.

Category	Annual limit (rem)	Dose ¹
General employees	5	Whole body (internal plus external)
	50	Any organ (other than eye) (internal plus external)
	15	Lens of the eye
	50	Extremities and skin
Embryo/fetus of a declared pregnant worker	0.5	Internal plus external (evenly distributed throughout gestation)
Occupationally exposed minors	0.1	Whole body (internal plus external)
	1.5	Lens of the eye
	5	Extremities and skin
Members of the public	0.1	Whole body (internal plus external)

¹ The official dose terminology is provided in Document 20.5, "Occupational Radiation Protection: Implementation of 10 CFR 835," in the *ES&H Manual*.

3.4 Written Authorizations, Safety Plans, and Operating Procedures

Written plans and procedures (e.g., safety plans and operating procedures) shall be developed and implemented as necessary to ensure compliance with the Rule. These plans and procedures shall be commensurate with the radiological hazards created by the activity and consistent with the education, experience, training, and skills of the individuals exposed to those hazards.

A written authorization (e.g., an Integration Work Sheet [IWS]) is required to control entry into and to perform work within Radiological Areas (e.g., Contamination/High Contamination Areas, Airborne Radioactivity Areas, Radiation/High Radiation Areas).

A facility safety plan or IWS/SP is required

- To document deviations from the requirements of this document. Deviations shall be consistent with LLNL's RPP and the ALARA process described in Document 20.4.
- **Note:** Only DOE can grant exemptions from the Rule's requirements.)
- For any minor who handles radioactive material, operates an RGD, or works in an area where he/she is likely to receive 50 percent of the allowable dose limit for a minor (see Table 2).
- For work with or storage of radioactive materials as specified in Document 20.2.
- As required for radiation generating device (RGD) operations as specified in Document 20.3.

Note: Document 2.4, "Construction Subcontractor Environment, Safety, and Health Program," in the *ES&H Manual* contains a sample work permit for short-term (i.e., less than 1 year) work conducted by non-LLNL workers.

Written procedures other than safety plans may be necessary to control complex or high-consequence operations, particularly if large numbers of individuals or inexperienced workers are involved. Written procedures shall be developed and employed if any of the following circumstances apply:

- Worker health and safety are directly affected.
- The expected outcome for the process or operation requires that a specific method or sequence be followed.
- The process or operation is infrequently used and competence training cannot assure adequate implementation.
- As needed to document the approved method to implement specific processes or operations.

For example, if a highly contaminated glovebox is to be moved from one location to another, it is imperative that safety measures are in place and certain aspects of the operation occur before others (e.g., that temporary ventilation control is provided before the glovebox is removed from the house ventilation system). Detailed safety plans (e.g., work permits) may be used to accomplish the specific steps of the overall operation; however, an umbrella procedure should be used to tie the individual work permits together and ensure sequence-critical portions of the overall operation occur in the correct order. The authorizing program is responsible for identifying operations that require written procedures and shall work with ES&H teams to ensure that appropriate procedures are written and implemented.

3.5 Timeframes for Completing Required Tasks

The Rule requires internal audits to be completed at least every 36 months, radiation training to be completed at least every 24 months, and sealed radioactive sources to be inventoried and leak tested every 6 months. These timelines may be extended for up to 30 days to accommodate scheduling needs.

4.0 Radiation Protection Standards

4.1 Occupational Dose Limits

Table 2 shows the dose limits for different categories of people. Doses from background radiation, therapeutic and diagnostic medical and dental exposures, and those resulting from participation as a subject in medical research programs are not included in dose records or when assessing compliance with the occupational dose limits.

4.2 Occupationally Exposed Minors

The ES&H Team health physicist shall evaluate all radiological work that is to be performed by minors. Minors shall only be permitted to perform tasks that are unlikely to result in exposures exceeding the relevant limits shown in Table 2. If a minor is likely to receive an occupational dose in excess of 10 percent of the relevant limit, the concurrence of the RSPL is required prior to the initiation of work.

4.3 Embryo/Fetus of a General Employee

All women who are pregnant, or plan or suspect a pregnancy, are strongly encouraged to contact the Health Services Department. The Health Services Department will

- Provide the woman with pregnancy-related information.
- Interview the woman to determine the potential for occupational exposure to workplace hazards.
- Issue a medical restriction limiting radiation exposure to 0.5 rem during the gestation if the woman works in a radiological or nuclear facility and agrees to the medical restriction. (Medical restrictions written to protect the embryo/fetus are issued only after the woman voluntarily signs a 'Declaration of Pregnancy' form and is informed of the ramifications of the restrictions.) A medical restriction may also be issued to control exposure to other workplace hazards. The woman may 'undeclare her pregnancy' at any time (thus removing the work restrictions that are in place solely for the protection of the embryo/fetus).
- Maintain written Declarations of Pregnancy, including the estimated date of conception, and revocations of Declarations of Pregnancy .
- Notify the ES&H Team of the medical restriction.

The appropriate members of the ES&H Team will conduct a workplace evaluation; the health physics portion of the workplace evaluation is described in Appendix C. The workplace evaluation – which can be conducted on a confidential basis if requested by the employee – helps ensure the embryo/fetus is afforded maximum protection. At any time, the employee may direct that the medical restriction (and any associated work or workplace modifications) be rescinded by providing written notification to the Health Services Department.

4.4 Planned Special Exposures

Provisions for planned special exposures, which are in addition to and accounted for separately from routine occupational doses, are described in Document 20.5.

4.5 Emergency Exposure Situations

Provisions for exceeding the normal occupational dose limits in response to an emergency exposure situation are described in Document 22.6, "Exposure to Radiation in an Emergency," in the *ES&H Manual*.

5.0 Posting Requirements

5.1 General

Posting, unposting, or altering of signs containing the radiation trefoil symbol shall only be done by, or under the direction of, the Hazards Control Department. Workers shall obey posted signs.

The *Radiation Safety Sign Manual*, maintained by the Hazards Control Department, contains approved radiological signs and labels as well as guidance for when and where they should be posted. Signs that were included in previous versions of this manual (1998 or later) are also acceptable as long as they meet the minimum posting requirements specified in the Rule. In case of ambiguity involving a specialty sign with the radiation trefoil symbol, the Hazards Control Department's RPP subject-matter expert (RPP-SME) determines whether the sign is consistent with the requirements. The RPP-SME shall concur with the posting of any newly-created sign containing the radiation trefoil symbol.

The Rule requires specific signs to be posted at each access point to various types of areas. The access point to a Radioactive Material Area, X-ray Area, Accelerator Area, or Airborne Radioactivity Area is typically the door(s) to the area. The access point to a Contamination Area or Radiation Area is typically the boundary of the area that requires posting. That is, one does not access the Contamination Area or the Radiation Area until one reaches the levels requiring posting as Radiation or Contamination Areas. If only a small portion of the room is a Radiation Area, that area should be physically or visually delineated and posted so workers are aware of the area conditions. Alternatively, the door to the room could be posted with the CAUTION Radiation Area sign and a map (or other means) identifying the location of the Radiation Area in the room. However, this method is less preferable than directly posting the access point to the area. Regardless of the methodology used, the location of the Radiation Area shall be obvious to workers in the room.

When posting access points to an area, the following apply:

- All access doors that can be opened from the outside shall be posted, even if the door remains locked. (This posting protects individuals such as Protective Service Officers (PSOs), firefighters, and other emergency responders who may enter the area using master keys.) Individuals who allow others to access an area through such doors shall ensure those entering the area abide by the access control requirements.
- Doors that cannot be opened from the outside (e.g., highbay rollup doors or emergency exits out of the Plutonium Facility) are only considered access points if they are left open and unattended.

- Side-by-side doors do not have to be individually posted if it is obvious that both doors provide access to the same area and an appropriate sign is clearly and conspicuously posted.

Posting requirements may be waived for periods of less than 8 continuous hours when the area is placed under the continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures. Signs and labels containing the radiation trefoil symbol shall be defaced or destroyed prior to being disposed of in the municipal trash. Posting and labeling requirements specific to radioactive materials and RGDs are contained in Document 20.2 and Document 20.3.

5.2 Radiologically Controlled Areas

A radiologically controlled area is any area where access is managed to protect individuals from exposure to radiation or radioactive materials. At LLNL, all areas posted with the radiation trefoil symbol are radiologically controlled areas. Individuals who only enter radiologically controlled areas without entering a Radiological Area are not expected to receive a whole-body dose exceeding 0.1 rem in a year. Each access point to a radiologically controlled area that is not a Radiological Area shall be conspicuously posted, as specified in the *Radiation Safety Sign Manual*, with one or more of the following signs:

- CAUTION Radioactive Materials Area.
- CAUTION Radiological Buffer Area.
- CAUTION X-ray Area.
- CAUTION Accelerator Area.

Note: Because individuals are not expected to receive doses in excess of 0.1 rem in a year in Radioactive Materials Areas without entering a Radiological Area, LLNL includes Radioactive Materials Areas in the general category of “radiologically controlled areas.”

5.3 Radiological Areas

Each access point to a Radiological Area (Radiation Areas, Contamination Areas, Airborne Radioactivity Areas) shall be clearly and conspicuously posted, as specified in the *Radiation Safety Sign Manual*, with one or more of the signs listed below. Individuals entering these areas could receive a dose in excess of 0.1 rem in a year. (Definitions for these areas can be found in Appendix A.)

- CAUTION Radiation Area.

- CAUTION/DANGER High Radiation Area.
- GRAVE DANGER Very High Radiation Area.
- CAUTION Contamination Area.
- CAUTION/DANGER High Contamination Area.
- CAUTION/DANGER Airborne Radioactivity Area.

6.0 Monitoring Individual Exposures

The Hazards Control Department shall maintain dose records for all individuals for whom monitoring is conducted. Records shall include doses received as a result of

- Routine occupational exposures.
- Planned special exposures.
- Authorized emergency exposures.
- Unplanned whole body doses exceeding 0.1 rem in a year.
- Unplanned shallow/extremity doses exceeding 5 rem in a year.

Documentation of all occupational doses received during the current year shall be obtained when determining compliance with the dose limits specified in the Rule. The Hazards Control Department shall also maintain the results of monitoring used to determine individual occupational dose from external and internal sources.

LLNL employees are responsible for providing the names and addresses of previous employers that have their occupational radiation dose records. LLNL shall make reasonable efforts (at least two written attempts) to obtain complete records of each individual's prior years occupational dose and, upon receipt, shall enter the information into the LLNL database. If complete records cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance with the Rule. Subcontractors are responsible for maintaining their employees' total doses below the applicable dose limits. Therefore, LLNL does not request dose histories for subcontractor employees. LLNL does, however, report the dose of each subcontractor employee directly to the subcontractor employee [if he or she has a mail stop (i.e., an L-code)] and to the subcontractor.

Dosimetry records, including detailed information, that are identified with a specific individual shall be readily available to that individual and to others (e.g., the individual's supervisor, management, and safety personnel) on a need-to-know basis.

Individuals can request their dosimetry records from the Hazards Control Dosimetry Team or the ES&H Team health physicist.

Upon request, LLNL shall provide dose records to an individual terminating employment as soon as the data are available, but not later than 90 days after termination. If requested, a written estimate of the radiation dose received by that employee (based on available information) shall be provided at the time of termination. If LLNL is required to send a report to DOE concerning an individual's exposure to radiation or radioactive material, that individual shall be provided a copy of the report at a time not later than the transmittal to DOE.

6.1 Internal Exposures

Requirements for internal dose monitoring are contained in Document 20.2.

6.2 External Exposures

All individuals employed at LLNL shall wear an LLNL-issued whole-body dosimeter. Others shall wear an LLNL-issued dosimeter if they enter an area posted with the radiation trefoil symbol. The Hazards Control Department is responsible for routinely issuing LLNL dosimeters. (The Badge Office issues the initial dosimeter to LLNL workers and to visitors.) Dosimeters issued by another DOE site should not be worn at LLNL. Visitors whose company's policy requires them to wear their own dosimeters (e.g., industrial radiographers operating under a state license) may do so but shall still wear the LLNL-issued dosimeter. The RPP-SME shall approve:

- Any alternate uses of dosimeters at LLNL.
- The use of LLNL dosimeters at other sites.

The RPP-SME may also establish alternate dosimeter requirements on a case-by-case basis (e.g., for individuals receiving diagnostic or therapeutic doses of radiation, for tour groups, and for general visitation days, such as Family Day and Bring Your Son/Daughter to Work Day.)

In general, LLNL dosimeters should not be worn at another site or facility within the United States. If a dosimeter is needed, the host facility or the sponsoring agency is responsible for supplying the dosimeter to the individual and informing the individual's employer of the results. The individual wearing the dosimeter is responsible for identifying the name and address of their employer.

The ES&H Team health physicist is responsible for determining the types of dosimeters that are required and the appropriate dosimeter exchange cycle. Program, service, and facility management is responsible for ensuring workers properly wear and exchange

the prescribed dosimeters. The requirements for dosimeters (other than the routinely issued whole-body dosimeters) should be documented (e.g., in the safety plan, RGD logbook, or Health Physics Discipline Action Plan [HP-DAP]). Appendix D contains information about the types of dosimeters used at LLNL, the requirements for their use, and the dosimeter results notification protocol.

LLNL-issued dosimeter packets (i.e., the dosimeter in the dosimeter holder with the plastic flap bearing the LLNL logo) shall be worn

- Facing out on the upper part of the body. The dosimeter packet should *not* be covered by other materials (including plastic cards) other than anticontamination (anti-C) clothing.
- Only at LLNL and by the person to whom it was issued.

Figure 1 shows an exploded view of a dosimeter packet. Figure 2 shows how the dosimeter packet should be configured with the security badge and other cards that may be carried.



Figure 1. Correctly configured dosimeter packet



Figure 2. Correctly configured dosimeter packet/security badge

Wearers should notify the Hazards Control Department promptly if the dosimeter is

- Exposed to nonoccupational sources of radiation (e.g., dental x-rays or medical procedures), excessive heat, or moisture.
- Lost or damaged.

6.3 Monitoring Considerations for Non-US Travel

LLNL work may require individuals to work in non-U.S. facilities in a wide variety of locations, capacities, and conditions. LLNL's goal is to assure, to the extent possible, that workers are provided at such non-U.S. facilities a standard of care similar to what they would receive if conducting similar work in the U.S. Although the host facility is responsible for providing visitors with appropriate monitoring and personal protective equipment and for reporting any assessed doses, it is LLNL's responsibility to ensure that LLNL workers are appropriately monitored while conducting work. Therefore, in some situations, it may be prudent for LLNL to supplement the monitoring provided by the host facility. Supplemental monitoring may include wearing an LLNL-issued dosimeter or participating in a pre- or post-trip bioassay program (which typically involves urinalysis, whole body/lung counting, or both).

The decision to provide supplemental monitoring for an individual or group of individuals working in a non-U.S. facility involves judgement and estimates of known and projected exposures. Responsible Individuals should use the following guidelines to determine whether travelers should contact their ES&H Team health physicist regarding upcoming or just-completed non-U.S. travel. The guidelines are also available at the following Internet address:

http://www-r.llnl.gov/es_and_h/foreign_travel/pdf/Non-US_Travel_Dosimetry.pdf

The ES&H Team health physicist assists the Responsible Individual in determining whether supplemental monitoring is needed and, if so, what type of monitoring is appropriate.

Contact the ES&H Team health physicist if there is any concern about unmonitored internal or external dose, or if the work involves being in a room or area where

- gram quantities of plutonium are stored or processed.
- kg quantities of uranium are stored or processed.
- Curie quantities of a radioactive material are handled.
- Radioactive material is processed in a glovebox.
- Respirators are worn, whether required or not.

- Dispersible (i.e., dusty or flaky) radioactive material is handled in an open area.
- Dust, smoke, or fire involving radioactive material or contaminated equipment exists.
- An accidental spread of surface or airborne contamination has occurred.
- An evacuation, fire, criticality, airborne, or other alarm sounds.
- An external dose of 50 mrem or an internal dose of 100 mrem [committed effective dose equivalent (CEDE)] is likely.
- Open-beam RGD operations are occurring, or you are working in close proximity to others who are operating x-ray- or neutron-generating equipment.
- Containers of dispersible radioactive material are opened while no respiratory protection is worn.

Consider contacting your ES&H Team health physicist if your work involves

- Entry into areas posted with radiological warning signs.
- Entry into areas where small to moderate quantities of radioactive materials are stored or processed (e.g., biomedical, chemistry, and radiation measurement laboratories).
- Work in close proximity to others who are handling more than 1 μCi (37 kBq) of radioactive material.
- Entry into areas where the dose rate exceeds 5 mrem/h (50 $\mu\text{Sv/h}$).
- Being in an area equipped with a radiation area monitor (RAM).

7.0 Monitoring the Work Environment

The Rule requires that monitoring of work areas be performed to

- Demonstrate compliance with the Rule.
- Document radiological conditions.
- Detect changes in radiological conditions.
- Detect the gradual buildup of radioactive material.
- Verify the effectiveness of engineered and process controls for containing radioactive materials and reducing radiation exposure.
- Identify and control potential sources of individual exposure to radiation and radioactive materials.

Hazards Control ES&H Team health and safety technicians are responsible for conducting and documenting the monitoring required by the Rule unless

- The ES&H Team leader, the work supervisor or Responsible Individual, and the RPP-SME agree, in writing, that another individual or organization will assume responsibility for conducting and documenting the surveys.
- The person(s) taking on the responsibility is specifically identified and trained to conduct the monitoring required by the Rule, and records of the surveys are stored or archived in the same manner as other survey records generated by the ES&H Team.

7.1 Portable Radiation-detecting Instruments (including CAMs and Hand and Shoe Monitors)

Instruments and equipment used for monitoring shall be

- Periodically maintained and calibrated on an established frequency (typically, annually).
- Appropriate for the types, levels, and energies of the radiation. The types of instruments appropriate for use in a facility are identified in the HP-DAP.
- Appropriate for existing environmental conditions. Appendix E of this document contains limiting environmental conditions.
- Routinely tested for operability. Instrument users shall perform a battery check and function test (as practicable) on instruments each time they are turned on.
- Tested on a calibration test jig prior to conducting documented beta-gamma surveys (e.g., those required by the HP-DAP) in High Radiation Areas and Radiation Areas routinely occupied by workers. Routine occupancy is considered to be at least 8 hours per week.

The Hazards Control Radiation Calibration Laboratory shall

- Obtain, maintain, calibrate, and distribute portable radiation-monitoring instruments used for health and safety purposes.
- Document the results of maintenance and calibration performed on instruments and equipment.

Organizations that choose to purchase portable radiation-monitoring instruments that are to be used for health and safety purposes shall

- Contact the Hazards Control Radiation Calibration Laboratory (RCL) prior to purchasing the instrument to determine if RCL can maintain and calibrate the instrument. The RCL can maintain instruments that are the same as instruments currently in their inventory.
- Arrange for a service contract with the vendor if the instrument cannot be maintained by the RCL.
- Ensure users of the instrument are trained.

7.2 Specific Monitoring Requirements

Specific monitoring requirements for radioactive materials and RGDs are contained in Document 20.2 and Document 20.3.

8.0 Access Controls

Access controls to areas posted with the radiation symbol include training (see Section 9.0) and the controls listed in this section.

Visitors who are minors

- May enter areas posted with the radiation symbol, except as noted below.
- Shall be escorted at all times by an adult who ensures compliance with LLNL's rules and policies.
- May not handle radioactive material or contaminated items without the specific concurrence of the RPP-SME.

8.1 Radiological Areas

Personnel entry control shall be maintained for each Radiological Area. The degree of control shall be commensurate with existing and potential radiological hazards within the area. One or more of the following control methods shall be used:

- Signs and barricades.
- Control devices on entrances.
- Conspicuous visual and/or audible alarms.

- Locked entrance ways.
- Administrative controls.

Controls that would prevent rapid evacuation of personnel under emergency conditions shall not be installed at any Radiological Area exit. Visitors who are minors are not permitted access to radiological areas without the specific concurrence of the RPP-SME.

8.2 High Radiation Areas

Access to High Radiation Areas shall be monitored as necessary to determine the exposure rates to individuals in the area. Hand-held radiation detectors should be used in addition to any installed RAMs because the area dose rates may vary significantly. In addition, a supplemental dosimeter is required for access to High Radiation Areas as specified in Appendix D. This dosimeter shall be capable of providing an immediate estimate of the individual's integrated deep dose equivalent during the entry. If a supplemental dosimeter is impractical or ineffective (e.g., when monitoring doses from neutron radiation), other means (e.g., knowledge of the area exposure rate and tracking of individual access times) may be used to provide an immediate estimate of an individual's dose. The ES&H Team health physicist should be present to provide radiation dosimetry support when personnel access High Radiation Areas produced by neutron radiation.

One or more of the following controls shall be used for each access point to a High Radiation Area if an individual's whole-body dose could exceed 1 rem in any one hour at 30 cm from the source or from any surface that the radiation penetrates:

- A control device that prevents entry into the area when high-radiation levels exist or that, upon entry, causes the radiation level to be reduced below that which defines a High Radiation Area.
- A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area.
- A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the High Radiation Area and the supervisor of the activity are made aware of the entry. The audible signal shall be of a frequency (or be capable of producing a sound-pressure level) that can be heard over background noise.
- Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained.
- Continuous, direct, or electronic surveillance that is capable of preventing unauthorized entry.

- A control device that will automatically generate audible and visual alarm signals to alert personnel in the area of the intended use or operation of the radiation source in sufficient time to either evacuate the area or activate a secondary control device that will prevent use or operation of the source.

Visitors who are minors are not permitted access to High Radiation Areas.

8.3 Very High Radiation Areas

In addition to the requirements in Section 8.2, the programmatic organization shall implement additional measures to ensure individuals are not able to gain unauthorized or inadvertent access to Very High Radiation Areas.

9.0 Training Requirements

Each individual shall complete radiation safety training, commensurate with the hazards in the area and the required controls,

- Before being permitted unescorted access to radiologically controlled areas (i.e., areas posted with the radiation trefoil symbol).
- Before receiving occupational dose during access to radiologically controlled areas (i.e., areas posted with the radiation trefoil symbol).

Furthermore, radiation safety training shall be provided to individuals

- At intervals not to exceed 24 months.
- When there is a significant change to radiation protection policies and procedures that may affect the individual.

Radiation safety training shall include the following topics to the extent appropriate to each individual's prior training, work assignments, and degree of exposure to potential radiological hazards:

- Risk of exposure to radiation and radioactive materials, including prenatal radiation exposure.
- Basic radiation fundamentals and radiation protection concepts.
- Controls for both routine and emergency actions implemented at the local level to manage and maintain doses as low as reasonably achievable (e.g., physical design features, administrative controls, limits, policies, procedures, alarms, and other measures).

- The individual's rights and responsibilities for implementing the facility's radiological protection program.
- The individual's responsibilities for implementing ALARA measures.
- Reports the individual may request.

If an escort is used in lieu of training, the escort shall have completed the training required for unescorted access to the area and shall ensure that all escorted individuals comply with the safety requirements of this document and its supplements.

Note: An escort does not obviate the requirement for training prior to receiving occupational exposure in a radiologically controlled area.

Records shall be maintained to demonstrate compliance with the training requirements in this section. Documentation of institutionally provided courses is contained in the Livermore Training Records and Information Network (LTRAIN).

9.1 Institutionally Required Training

Table 3 contains the Laboratory's institutional training requirements. Programs, facilities, or the ES&H Team health physicist may require additional radiological training for access or work in specific facilities. The definitive list of institutionally required courses and their alternates is contained in LTRAIN. If discrepancies exist, the LTRAIN list supersedes the courses listed in Table 3 and in other documents (e.g., FSPs and OSPs). Except where otherwise stated, retraining is required every 24 months.

9.1.1 General Employee Radiological Training

Since all individuals onsite have access to areas posted with the radiation trefoil symbol, LLNL requires all workers who are regularly assigned to work at LLNL to complete General Employee Radiological Training (GERT). The initial GERT course is provided during New Employee Orientation (course HS0001). . Retraining is completed by reading the booklet *Radiation Safety at LLNL*, which is mailed to all Laboratory and supplemental labor employees every 24 months.

Table 3. Radiation safety training courses. Core course numbers are provided. See LTRAIN catalog for alternate courses.

Course	Application
HS6001, "General Employee Radiological Training" (GERT) Retraining is achieved every 24 months by the mailing of a GERT booklet.	Required prior to receiving occupational dose in an area posted with the radiation symbol and for <ul style="list-style-type: none"> Unescorted access into a Radioactive Materials Area, X-ray Area, Accelerator Area, or Radiological Buffer Area (i.e., any area posted with the radiation trefoil symbol) Escorted access into a Radiation Area, High Radiation Area, Contamination Area, High Contamination Area, or Airborne Radioactivity Area.¹
HS6901, "Radiological Worker Core Training" or equivalent	Required for <ul style="list-style-type: none"> Unescorted access to Radiation Areas. Any person likely to received >0.1 rem/y who is not a radioactive material handler or radiation generating device (RGD) operator.
HS6010, "Radiological Worker" or equivalent	Required for <ul style="list-style-type: none"> Work with nondispersible radioactive material only. Unescorted access into a High Radiation Area, or Very High Radiation Area.
An HS6300 series course, "Contamination Control" or one of the radioactive material handling courses or equivalent	Required for <ul style="list-style-type: none"> Work with dispersible radioactive material. Unescorted access into a Contamination Area, High Contamination Area, or Airborne Radioactivity Area.
HS6340, "Anti-Cs"	Required for work where full anti-contamination clothing is necessary (i.e., coveralls with the openings taped, shoe covers, gloves, and a respirator).
HS6390, "Introduction to Glovebox Safety"	Required for work conducted in gloveboxes. Retraining is not required.
HS6913, "Chelation Therapy"	Recommended for glovebox work with transuranic radioactive material. This course is available upon request by the programs. Retraining is not required.
HS6070, "Safety and the X-ray Machine"	Required for users of Class II, III, or IV RGDs (other than accelerators) and personnel working in close proximity to these devices.
HS6911, "Radiological Worker Training for Accelerator Facilities"	Required for operators and personnel working in close proximity to accelerators.

¹ The dose limit for members of the public during access to a radiologically controlled area is 0.1 rem in a year.

Individuals (including LLNL workers and visitors) who have not completed GERT

- May be *escorted* by a GERT-trained worker into a Radioactive Materials Area, X-ray Area, Accelerator Area, or Radiological Buffer Area.

- Are *prohibited* from entering Radiological Areas (e.g., Radiation Areas and Contamination Areas).
- Are *prohibited* from working with radioactive materials and RGDs, even if under the escort or direct guidance of a trained and qualified radiological worker.

Visitors may complete GERT by reading *Radiation Safety at LLNL* and filling out the card on the back cover, or may complete the CBT version of course HS6001.

Pamphlets can be obtained by calling “2-GET1” (2-4381), or by stopping by the Badge Office or the Hazards Control Department’s Safety Education and Training Section.

9.1.2 Radiological Worker Training

Radiological worker training is required before performing independent work as a radiological worker and before being permitted unescorted access to Radiological Areas. (Radiological Areas are posted as specified in Section 5.3.) Workers who have completed GERT, but who have not completed radiological worker training, or whose radiological worker training has lapsed, may

- Be escorted into posted Radiation Areas and Contamination Areas by a trained radiological worker if entry is not expected to result in an individual dose exceeding 0.01 rem in a day or 0.1 rem in a year.
- Handle radioactive materials (including potentially contaminated items) only under the direct guidance of a trained and qualified coworker. The following restrictions apply:
 - Each trained worker may provide direct guidance to only one individual at a time, unless prior approval is obtained from the ES&H Team.
 - The person providing direct guidance shall cosign (or initial) any documents generated by the untrained person.
 - The ES&H Team member who is providing ES&H oversight shall not serve as the trained and qualified coworker.

Working under the direct guidance of a trained and qualified worker is intended to provide a reasonable means of allowing work to continue while training is in process. It is not an approved means of bypassing training. The work supervisor or Responsible Individual is responsible for documenting the limitation of the person requiring direct guidance and for ensuring both the person and the worker providing guidance understand their responsibilities.

Radiological workers may provide direct guidance to subcontractors (e.g., a factory repairperson conducting limited work at LLNL) contingent upon the approval of programmatic management and the ES&H Team. A radiological work permit for use by subcontractors is available in Document 2.4.

Some DOE sites use the terms “radiological worker I” (RW-I) and “radiological worker II” (RW-II) in describing levels of training. However, the terms are not used at LLNL, because most LLNL workers require a level of training that is between an RW-I and RW-II (e.g., an HS6300 series course) or not included in RW-I or RW-II (e.g., the RGD courses). The Hazards Control Department’s Safety Education and Training Section can issue RW-I and RW-II reciprocity cards for work at other sites, but the cards are not to be used to establish a worker’s training status for LLNL-required courses.

9.2 Locally Required Training

Additional training (i.e., training beyond that which is provided institutionally) is required where individual ALARA goals are established, area radiation alarms are installed, or safety plans are used to control radiological operations. This training shall encompass both routine and emergency conditions, physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the local level to manage and maintain doses as low as reasonably achievable.

The following activities may be used singularly or in combination to fulfill additional training requirements:

- A review of applicable safety plans.
- A review of operating procedures.
- Facility-specific orientations or safety briefings.
- On-the-job (hands-on) training.

The Responsible Individual shall ensure that local training requirements are identified, workers requiring local training are identified, and completed training is documented.

10.0 Records

Records that are generated as a result of the requirements of the Rule shall be retained until DOE authorizes their disposition. Appendix F specifies the responsibilities for record generation and maintenance.

11.0 Responsibilities

All workers and organizations shall refer to Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *ES&H Manual* for a list of general responsibilities. This section describes specific responsibilities of LLNL organizations and workers who have key safety roles.

The responsibilities of individuals and organizations with regards to occupational radiation protection are specified below each title. Responsibilities that are specific to the ALARA program, radioactive materials, or RGDs are included in Document 20.4, Document 20.2, and Document 20.3.

11.1 Program Associate Director

The program associate director shall ensure radiological operations are conducted in compliance with this document. In addition, the program associate director shall:

- Keep track of incidents or occurrences and notify DOE when required.
- Consult with the LLNL Price Anderson Amendments Act (PAAA) Office regarding findings or occurrences that may be reportable under the PAAA requirements.

11.2 Payroll Supervisor

The payroll supervisor shall ensure the LTRAIN questionnaire for radiological workers is updated at least annually and any work restrictions that result from lapsed training are documented.

11.3 Authorizing Individual

The authorizing individual shall

- Provide adequate resources for effective implementation of the Radiation Safety Program.
- Be aware of potentially hazardous radiological conditions or activities, and ensure that radiation safety in general and ALARA principles in particular are not compromised for the expediency of experiments or operations.
- Ensure the ALARA process is integrated into radiological operations.
- Participate in internal audits required by the Rule.
- Ensure records are maintained as specified in Appendix F of this document.

11.4 Work Supervisor or Responsible Individual

The work supervisor or Responsible Individual shall

- Integrate into operations the requirements and controls specified in this document and its associated documents, along with any additional requirements identified by the ES&H Team.
- Maintain a radiologically safe work environment and take corrective actions if potentially hazardous conditions arise.
- Maintain documentation of ALARA considerations included in procedures and design modifications.
- Develop plans to minimize personnel exposure to radiation under accident or emergency conditions.
- Implement access controls for Radiological Areas.
- Control operations so doses are kept as low as reasonably achievable below the dose limits.
- Provide workers with the appropriate tools and protective equipment and ensure their proper use.
- Ensure procedures are implemented and used effectively.
- Identify operations that require written plans or procedures (e.g., safety plans or operating procedures) and assist in the development of those plans and procedures to ensure compliance with the Rule.
- Provide job-specific training for unique hazards associated with radiological work.
- Ensure the radiological facility and program training requirements are identified and documented (i.e., included in the LTRAIN questionnaire).
- Notify the payroll supervisor of any inaccuracies or discrepancies found in the worker's LTRAIN questionnaire.
- Ensure workers
 - Follow established safety plans and procedures.
 - Wear the prescribed dosimeter and personal protective equipment.
 - Are current in all required training.
- If a minor is hired to do radiological work, notify the Hazards Control Department of the person's work assignment.

- Make the workplace modifications necessary to accommodate workers' pregnancy-related medical restrictions.
- Notify the facility point of contact, facility manager, or assurance manager of any DOE-reportable events or conditions that may require an Occurrence Report (e.g., loss of control of radioactive materials, contamination outside of designated areas, inability to locate an accountable sealed radioactive source). For more information, see Document 4.5, "Incidents – Notification, Analysis, and Reporting," in the *ES&H Manual*.
- Provide input to Occurrence Reports.

11.5 Employees

11.5.1 All Individuals

All individuals shall

- Obey posted radiological requirements.
- Be current in the training required for unescorted access to radiologically controlled areas, or be escorted by a trained worker.
- Wear dosimeters as prescribed and exchange the dosimeters promptly when a new one is received.
- Comply with this document and its associated documents when conducting radiological work.

11.5.2 Radiological Workers

All radiological workers shall

- Be aware of
 - The safety standards and requirements applicable to their work.
 - Their year-to-date accumulated dose and the radiation levels associated with the work to be done.
 - Potential radiation-related hazards in their work area and the applicable safety controls.
 - The recommendation to contact the Health Services Department if planning a pregnancy, or upon positive diagnosis of pregnancy. Such workers shall also decide whether or not to submit a Declaration of Pregnancy form. (This is separate and distinct from contacting the Health Services Department and is available in the ES&H Forms Repository.)

- Implement the controls specified in this document and its associated documents and plans and procedures associated with radiological work (e.g., safety plans and operating procedures).
- Control operations so that doses do not exceed the radiation protection standards and are kept as low as reasonably achievable.
- Provide bioassay samples on the frequency specified.
- Be current in all required radiological training before beginning work, or work under the direct guidance of a trained worker.
- Conduct ongoing operational surveys and any programmatically required surveys (e.g., surveys of hands and work areas during radioactive material-handling operations, surveys around RGDs to verify the radiation levels).
- Discontinue operations that are inconsistent with ALARA principles.
- Report to the program supervisor, facility point of contact, or the ES&H Team any workplace situations that require attention (e.g., unsafe conditions, spills, accidents, or injuries) and any event or condition that might be reportable under the DOE Occurrence Reporting System (see Document 4.3, "LLNL Implementation Procedures for DOE Order 232.1A – Occurrence Reporting and Processing of Operations Information," in the *ES&H Manual*).

11.6 Hazards Control Department

11.6.1 ES&H Teams Division

The ES&H Team leader shall

- Negotiate with program and facility management the appropriate levels of funding and staffing support so that the necessary resources are available to implement the ES&H Team requirements and controls specified in this document and its associated documents.
- Inform program and facility management of potential vulnerabilities if adequate resources are not provided to meet compliance requirements.
- Ensure the HP-DAP is effectively implemented.
- Ensure records are maintained, as specified in Appendix F of this document.

The ES&H Team health and safety technician shall

- Assist program, facility, and service workers with implementing the compliance requirements specified in this document and its associated documents.
- Fulfill the posting and monitoring requirements of the Rule. This includes
 - Conducting routine radiation and contamination monitoring prescribed in the HP-DAP.
 - Maintaining documentation of field monitoring (e.g., swipes counted on field-swipe counters, radiation surveys, and equipment release surveys).
 - Ensuring areas are properly posted.
- When observing work in progress, inform the worker, the program supervisor, or the ES&H Team health physicist of actions or operations that are inconsistent with procedures or best management practices.
- Respond to radiological alarms, spills, accidents, and emergencies.
- Notify the facility point of contact (or the facility manager) and the ES&H Team leader of incidents or conditions that may warrant their attention.

The ES&H Team health physicist shall

- Evaluate radiological operations and ensure safety plans describe
 - The magnitude of radiological hazards.
 - The physical and administrative controls required for maintaining personnel doses, effluent discharges, and contamination levels as low as reasonably achievable.
- Establish external personnel radiation dose monitoring requirements, including the type of dosimeter required and the appropriate exchange frequency.
- Provide input for the development of emergency plans and procedures, as requested.
- Respond to radiological spills, accidents, and emergencies.
- Provide radiological safety oversight.
- Provide technical support to program and facility organizations that is consistent with the ALARA process.
- Identify area monitoring requirements and document them in the HP-DAP.

- Review and update (as necessary) the HP-DAP annually, or more frequently if needed.
- Conduct workplace evaluations for minors and workers with pregnancy-related medical restrictions. This includes
 - Recommending work or workplace modifications.
 - Documenting the interview in the worker's dosimetry file using the forms and guidance provided by the RPP-SME.
- Assist in the development and delivery of additional radiological training.

11.6.2 Radiation Safety Section

The RSS shall

- Maintain this document.
- Develop and disseminate radiation safety direction for LLNL that is consistent with LLNL policies and regulatory requirements.
- Authorize individuals who are not a part of the ES&H Team to conduct and document surveys required by 10 CFR 835.
- Coordinate internal audits required by the Rule.
 - At the end of each 3-year internal audit cycle, compile the issues raised in the individual audits and present a comprehensive report to LLNL management.
 - Maintain associated documentation.
 - Assist programs in determining if deficiencies warrant a PAAA report to DOE.
- Authorize deviations from LLNL's dosimeter requirement.
- Function as the subject-matter expert for interpretation and implementation of the Rule's requirements.
- Provide technical support to the ES&H Team health physicists.
- Upon request, determine whether work activities comply with the requirements in this document, its associated documents, and the RPP.
- Concur with access to Radiation Areas by visitors who are minors.
- Maintain the *Radiation Safety Sign Manual* and determine whether specialty posting and labeling comply with the Rule.
- Issue personnel dosimeters for routine use and maintain documentation of the dosimeter records.

- Maintain documentation of all analytical results evaluated by the respective laboratories.
- Provide termination dose reports for individuals with external doses.
- Provide the annual dose report to DOE and to individuals.
- Maintain the capability to analyze nuclear accident dosimeters and biological materials following a criticality accident.

(Radiation Measurements Laboratory)

Safety Education and Training Section trainers shall

- Develop, present, and document institutionally required radiological worker training.
- Train and qualify ES&H Team health and safety technicians (and other specifically identified individuals) to carry out the monitoring requirements of the Rule.

11.7 Other Laboratory Organizations

11.7.1 Human Resources

Human Resources shall notify the assurance manager, work supervisor or Responsible Individual, or Responsible Individual about any minors who are to perform work at LLNL.

11.7.2 Price Anderson Amendments Act Office

The PAAA Office shall assist programs in determining whether deficiencies warrant issuance of a PAAA report to DOE.

11.7.3 Assurance Review Office

The Assurance Review Office shall verify that corrective actions identified in the internal audits required by the Rule have been addressed by the responsible organization and closed out in the Deficiency Tracking (DefTrack) System.

12.0 Work Standards

10 CFR 835, "Occupational Radiation Protection." (Issued November 4, 1998, effective December 4, 1998).

13.0 Resources for More Information

13.1 Contacts

For additional information about the Radiation Safety Program at LLNL, workers should contact the following:

- Work supervisor or Responsible Individual.
- Authorizing Individual (a designated manager in the facility, program, or service line).
- ES&H Team health and safety technician.
- ES&H Team health physicist.
- ES&H Team leader.
- Hazards Control's RPP-SME.
- Hazards Control RSPL.

Hazards Control Department personnel can be reached through the ES&H Contact List.

13.2 Applicable Lessons Learned

The "Radiation Protection" category of the Lessons Learned Program contains information pertinent to occupational radiation protection. The Lessons Learned Program is available on the Internet at the following Internet address:

http://www-r.llnl.gov/es_and_h/lessons/lessons.shtml

13.3 Other Sources

For additional information about topics discussed in this document, refer to the *ES&H Manual* documents listed below. The official version is available on the Internet at

http://www.llnl.gov/es_and_h/esh-manual.html

Document 2.4, "Construction Subcontractor Environment, Safety, and Health Program."
(This document contains work permits for short-term work conducted by non-LLNL workers.)

Document 3.3, "Operational and Facility Safety Plans."

Document 4.2, "Environmental, Safety, and Health Deficiency Tracking System."

Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials."

Document 20.3, "LLNL Radiological Safety Program for Radiation-Generating Devices."

Document 20.4, "LLNL Occupational Radiation Protection ALARA Program."

Document 20.5, "Occupational Radiation Protection: Implementation of 10 CFR 835."

Document 22.6, "Exposure to Radiation in an Emergency."

Radiation Safety at LLNL (UCRL-TB-104702 Rev 4).

Other documents (located in the Hazards Control Department) used by the ES&H Team include the following:

Radiation Safety Sign Manual.

Hazards Control Manual.

Guidance from the following documents has been incorporated into this document wherever feasible:

DOE G 441.1-1, "Radiation Protection Program Guide," *10 CFR 835 Implementation Guide* (Formerly G-10 CFR 835/B1-Rev 1).

DOE G 441.1-12, "Radiation Safety Training Guide," *10 CFR 835 Implementation Guide* (Formerly G-10 CFR 835/J1-Rev 1).

DOE G 441.1-4, "External Dosimetry Program Guide," *10 CFR 835 Implementation Guide* (Formerly G-10 CFR 835/C2-Rev 10).

DOE G 441.1-10, "Posting and Labeling for Radiological Control Guide," *10 CFR 835 Implementation Guide* (Formerly G-10 CFR 835/G1-Rev 1).

DOE G 441.1-11, "Occupational Radiation Protection Record-Keeping & Reporting Guide," *10 CFR 835 Implementation Guide* (Formerly G-10 CFR 835/H1-Rev 1).

DOE G 441.1-6, "Evaluation and Control of Radiation Dose to the Embryo/Fetus Guide," *10 CFR 835 Implementation Guide* (Formerly G-10 CFR 835/C4-Rev 1).

DOE G 441.1-7, "Portable Monitoring Instrument Calibration Guide," *10 CFR 835 Implementation Guide* (Formerly G-10 CFR 835/E1-Rev 1).

Appendix A

Acronyms, Terms, and Definitions

The terms and definitions provided in this appendix are specific to their use in this document.

ALARA	See “As low as reasonably achievable.”
As low as reasonably achievable (ALARA)	An approach to radiation protection to manage and control individual and collective dose to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable limits as is reasonably achievable.
Background radiation	<p>Radiation from:</p> <ul style="list-style-type: none">• Naturally occurring radioactive materials that have not been technologically enhanced.• Cosmic sources.• Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices).• Radon and its progeny in concentrations or levels existing in buildings or the environment that have not been elevated as a result of current or prior activities.• Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.
Calibration	<p>To adjust or determine either</p> <ul style="list-style-type: none">• The response or reading of an instrument relative to a standard (e.g., primary, secondary, or tertiary) or to a series of conventionally true values.• The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true value.

CEDE	See “Committed effective dose equivalent.”
Committed dose equivalent ($H_{T,50}$)	The dose equivalent calculated to be received by a tissue or organ over a 50-year period after intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem.
Committed effective dose equivalent (CEDE)	The sum of the committed dose equivalent to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor (w_T) – that is, $H_{E,50} = \sum w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem.
Contamination Area	Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed (but do not exceed 100 times) the removable surface contamination values specified in Appendix D of Document 20.2, “LLNL Radiological Safety Program for Radioactive Materials,” in the <i>ES&H Manual</i> .
Declared pregnant worker	A woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo/fetus as provided in 10 CFR 835.206. The declared pregnant worker may revoke this declaration, in writing, at any time.
Deep dose equivalent	The dose equivalent derived from external radiation at a depth of 1 cm in tissue.
Direct guidance	For the purpose of the Rule, direct guidance requires a fully trained co-worker or supervisor to be in audible or visual contact with the worker who is not fully trained so that guidance and assistance can be readily provided if necessary. The level of supervision shall be commensurate with the hazards of the operation and the level of training completed by the worker.
Dose	A generic term for absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent.
Dose equivalent (H)	The product of absorbed dose (D) in tissue, a quality factor (Q), and other modifying factors (N). Dose equivalent is expressed in units of rem.

Effective dose equivalent (H_E)	The summation of the products of the dose equivalent received by specified tissues of the body (H_T) and the appropriate weighting factor (w_T)—that is, $H_E = \sum w_T H_T$. It includes the dose from radiation sources internal and external to the body. For purposes of compliance with the Rule, deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures. The effective dose equivalent is expressed in units of rem.
External dose or exposure	That portion of the dose equivalent received from radiation sources outside the body (i.e., external sources).
Extremity	Hands and arms (below the elbow) or feet and legs (below the knee).
General employee	<p>An individual who is either a DOE employee, a DOE contractor employee, an employee of a subcontractor to a DOE contractor, or an individual who performs work for or in conjunction with DOE or utilizes DOE facilities.</p> <p>At LLNL, this definition means an individual who is either a UC or a UC contractor employee, an employee of a subcontractor to LLNL, or an individual who performs work for or in conjunction with LLNL operations.</p>
GERT	General Employee Radiological Training.
High Contamination Area	Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Appendix D of Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials," in the <i>ES&H Manual</i> .
High Radiation Area	Any area, accessible to individuals, where radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem in one hour at 30 cm from the radiation source or from any surface that the radiation penetrates.
Internal dose or exposure	That portion of the dose equivalent received from radioactive material taken into the body (i.e., internal sources).

Member of the public	An individual who is not a general employee. An individual is not a member of the public during any period in which he/she receives an occupational dose.
Minor	An individual less than 18 years of age.
Monitoring	The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.
Occupational dose	An individual's ionizing radiation dose (external and internal) as a result of his/her work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.
PAAA	Price Anderson Amendment Act.
Radiation	Ionizing radiation: alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in the Rule, does not include nonionizing radiation (e.g., radiowaves, microwaves, or visible, infrared, or ultraviolet light).
Radiation Area	Any area, accessible to individuals, where radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (5 mrem) in one hour at 30 centimeters from the source or from any surface that the radiation penetrates.
Radioactive material transportation	The movement of radioactive material by aircraft, rail, vessel, or highway vehicle that is governed by DOT regulations or DOE orders. Radioactive material transportation does not include preparation or packaging of material for transportation, monitoring required by the Rule, storage of material awaiting transportation, or application of markings and labels required for transportation.

Radiological Area	Any area within a controlled area defined as a Radiation Area, High Radiation Area, Very High Radiation Area, Contamination Area, High Contamination Area, or Airborne Radioactivity Area.
Radiologically controlled area	Any area where access is managed to protect individuals from exposure to radiation or radioactive material.
Radiological worker	A general employee whose job assignment involves operating RGDs or working with radioactive materials, or who is likely to receive a total effective dose equivalent above 0.1 rem per year from routine occupational exposures.
RAM	Radiation area monitor.
RGD	Radiation-generating device.
RPP	<i>Radiation Protection Program.</i>
RSPL	Radiation Safety Program Leader
Safety plan	A document identifying the hazards and requisite controls associated with an operation or facility. Safety plans are approved by authorizing organization and, for the purpose of compliance with the Rule, may include, but are not limited to, facility safety plans (formerly known as facility safety procedures), operational safety plans (formerly known as operational safety procedures), standard operating procedures, work permits, radiation work permits, integration work sheets, and hazard assessment and control documents.
Shall	A mandatory requirement. Exemptions from contractual and regulatory requirements are obtained through the process described in Document 2.3, "LLNL Exemption Process," in the <i>ES&H Manual</i> .
Shallow dose equivalent	The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.
Should	A recommended practice. Can also indicate a desirable or best management practice. Written justification for declining to implement a "should" statement is not required.

SME	Subject-matter expert.
TEDE	See “Total effective dose equivalent.”
Total effective dose equivalent (TEDE)	The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
Very High Radiation Area	Any area accessible to individuals where radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads in one hour at 1 m from a radiation source or from any surface that the radiation penetrates.
Weighting factor (w_T)	The fraction of the overall health risk, resulting from uniform, whole-body irradiation, attributable to specific tissue (T). The dose equivalent to tissue (H_T) is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue. The weighting factors are provided in Document 20.5, “Occupational Radiation Protection: Implementation of 10 CFR 835,” in the <i>ES&H Manual</i> .
Whole body	For the purposes of external exposure, any exposure to the head, trunk (including male gonads), arms (above and including the elbow), or legs (above and including the knee).

Appendix B

Conducting Internal Audits

To ensure a comprehensive evaluation, both institutional and facility-specific audits are conducted. Institutional audits evaluate

- Management and administration.
- The ALARA Program.
- Radiological training.
- Internal dosimetry.
- External dosimetry (including the Declared Pregnant Worker Program).
- Instrument calibration and maintenance.
- Radiation-generating devices.
- Sealed source accountability.

Facility audits focus on how the radiological protection program is implemented in facilities, and include both facility and programmatic implementation of radiological requirements. Facility audits evaluate

- Documents used to implement the Rule's requirements (e.g., safety plans and HP-DAPs).
- Implementation of the ALARA Program.
- Individual monitoring, including appropriate use of dosimeters and enrollment and participation in bioassay programs.
- Area monitoring, including air monitoring, contamination monitoring, and radiation monitoring.
- Control of potentially contaminated items or areas.
- Access controls.
- Radioactive material controls.
- Posting and labeling.
- Additional training.

- Records generated as a result of the Rule's requirements (as specified in Appendix F of this document).
- Design and control of facility modifications and equipment.

The Radiation Safety Section of the Hazards Control Department is responsible for coordinating and conducting the audits. At the end of each 3-year audit cycle, the Radiation Safety Program Leader presents a comprehensive report to LLNL management.

Program management shall participate in the facility's internal audits, including supplying an account number, as requested. Management shall also respond to findings and concerns and, in conjunction with the PAAA Office, determine whether deficiencies warrant submission of a PAAA report.

The guidelines in Document 4.2, "Environmental, Safety, and Health Deficiency Tracking (DefTrack) System," in the *ES&H Manual* shall be used to document the audit.

Facility Management is responsible for entering all 10 CFR 835 internal audit deficiencies into DefTrack and ensuring that corrective actions are implemented. The Assurance Review Office is responsible for verifying that the audits are taking place on the appropriate frequency. In the case where no deficiencies are noted during the internal audit, the facility manager is responsible for recording completion of the assessment in the DefTrack database. Records shall be maintained to document the results of internal audits and other reviews of the radiological protection program content and implementation.

Appendix C

Workplace Evaluations for Pregnant Workers

The health physics portion of the workplace evaluation includes the following elements:

- Discussing with the woman her current dose, work assignment, and the likelihood of receiving occupational exposure during pregnancy as a result of normal and off-normal operations.
- Recommending work or workplace modifications that ensure the
 - Dose received during the gestation period is maintained as low as reasonably achievable below 0.5 rem.
 - Rate of dose accrual is limited to approximately 0.05 rem per month once the pregnancy is declared.
 - Monthly dose rate is limited and managed to assure the 0.5 rem embryo/fetus dose limit is not exceeded during the entire gestation period from the estimated date of conception. Woman is enrolled in a monthly dosimeter exchange cycle and an appropriate bioassay program if there is a potential for internal exposure.
- Documenting the interview and workplace evaluation and sending a copy of the documentation to the Personnel Dosimetry Team and to Health Services Department.

Program, facility, and service management shall make reasonable modifications to ensure the woman's dose is as low as reasonably achievable. If these modifications do not adequately reduce the risk, the woman can be assigned to a different job while the medical restriction is in effect. If the dose to the embryo/fetus has already exceeded 0.5 rem by the time a woman declares her pregnancy, the woman shall not be assigned to tasks where additional occupational exposure is likely during the remaining gestation period. The woman shall concur with any changes made as a result of the medical restriction. Such changes shall not affect her benefits, seniority, or potential for promotion.

Appendix D

Dosimeter Requirements and Results Notification Protocol

The following four types of whole-body dosimeters are used at LLNL:

- **Panasonic 802 dosimeters** (identified by a dosimeter holder with a blue front) should be worn by individuals *not* likely to receive a neutron dose because they are not tested by the DOE Laboratory Accreditation Program (DOELAP) for neutron exposure. These dosimeters are typically exchanged semiannually.
- **Panasonic 810 dosimeters** (identified by a dosimeter holder with a black front) shall be worn by individuals who may receive a neutron dose but are not likely to receive a neutron dose in excess of 0.05 rem (50 mrem) in a year. These dosimeters are typically exchanged monthly or quarterly.

Note: Individuals who work with radioactive materials or RGDs should be assigned an 810 dosimeter.)

- **Panasonic 810/CR-39 dosimeters** (identified by a dosimeter holder with a black front and white plastic on the back) shall be worn by individuals who are likely to receive a neutron dose in excess of 0.05 rem (50 mrem) in a year. These dosimeters are typically exchanged monthly.
- **Nuclear Accident Dosimeters (NADs)** (identified by a dosimeter holder with filled cavities bordering the hole provided for the Panasonic dosimeter). These dosimeters shall be worn in combination with one of the dosimeters described above by individuals entering areas where a criticality accident is possible. NADs are only read in case of a nuclear accident.

LLNL's NADs can be surveyed with a hand-held radiation detector to determine whether individuals present in the facility during a nuclear accident have been exposed to significant levels of radiation. The Hazards Control Department typically conducts this survey and shall maintain methods and equipment for analyzing NADs and biological materials.

Dosimeters should be exchanged at the following intervals:

- **Monthly** – For workers who are likely to receive a measurable external radiation dose under normal conditions (e.g., plutonium handlers), or who could receive a radiation dose under off-normal conditions and might not otherwise be aware of it (e.g., RGD operators). The ES&H Team health physicist investigates lost dosimeters that are exchanged monthly.
- **Quarterly** – For workers who handle radioactive material or operate RGDs but are *not* likely to receive a measurable external radiation dose under normal conditions (e.g., HWM workers and Class I and II RGD operators), or who would otherwise be aware of off-normal conditions that may result in

radiation exposure. The ES&H Team health physicist investigates lost dosimeters that are exchanged quarterly.

- **Semiannually** – For workers who are *not* likely to receive a measurable external radiation dose under normal conditions (e.g., office workers). The ES&H Team health physicist may or may not investigate lost dosimeters that are exchanged semiannually.

Table D-1 shows the Rule's requirements and additional LLNL requirements for wearing various types of dosimeters. Table D-2 shows the protocol for reporting dosimeter results to LLNL employees, supplemental labor, and visitors.

Table D-1. Dosimeter requirements.

Dosimeter type	Shall be worn by	
	10 CFR 835 requirements	Additional LLNL requirements
Whole-body dosimeter	<ul style="list-style-type: none"> • Radiological workers who, under typical conditions, are likely¹ to receive any of the following: <ul style="list-style-type: none"> – A deep dose equivalent exceeding 0.1 rem in a year. – A shallow dose equivalent to the skin of 5 rem or more in a year. – An eye dose equivalent of 1.5 rem or more in a year. • Individuals entering a High or Very High Radiation Area. • Declared pregnant workers who are likely to receive a dose exceeding 0.05 rem to the embryo/fetus. • Minors and members of the public who are likely to receive a whole-body dose exceeding 0.05 rem in a year. 	<ul style="list-style-type: none"> • All onsite LLNL employees and supplemental labor employees. • Anyone entering an area posted with the radiation trefoil symbol, except where a dosimeter is incapable of measuring the radiation (e.g., tritium).
Extremity dosimeters	Radiological workers who are likely to receive an extremity dose of 5 rem or more in a year.	Radiological workers who are likely to receive an extremity dose of 1 rem or more in a year.
Supplemental dosimeter ²	Individuals entering a High Radiation Area.	—
Nuclear Accident Dosimeters (NADs)	Individuals entering areas where a criticality accident is possible.	Individuals entering the Plutonium Facility Radioactive Materials Area.

¹ "Likely" may be determined by reviewing historical dosimetry records or by calculation.

² The dosimeter shall be capable of providing an immediate estimate of the individual's integrated deep dose equivalent during the entry. Where a supplemental dosimeter is impractical or ineffective (e.g., when monitoring doses from neutron radiation), other means (e.g., knowledge of the area exposure rate and tracking of individual access times) may be used to provide immediate indication of an individual's dose.

Table D-2. Protocol for reporting LLNL dosimeter results.

Individual	Notification protocol
LLNL employees and supplemental labor	<p>The worker and ES&H Team health physicist are notified of positive doses in approximately 30 days of the dosimeter being read.</p> <p>The ES&H Team health physicist is notified the day the dosimeter is read if the dose exceeds a certain threshold. The health physicist conducts an exposure investigation.</p> <p>An annual summary dose report is provided to the worker whether or not a dose is received.</p>
Visitors who indicate (when they fill out the dosimeter information card) they will work with radiation during their visit	A dose report is provided to the employer in approximately 30 days of the dosimeter being read.
Visitors who do <i>not</i> indicate they will work with radiation during their visit	<p>For positive doses, the employer (not the worker) is notified in approximately 30 days of the dosimeter being read.</p> <p>If no dose is received, a dose report is not provided.</p>

Appendix E

Environmental Boundaries for Radiation Detectors

Instruments used for radiation monitoring and contamination control shall be appropriate for the existing environmental conditions. Instruments should respond accurately when used in the pressure, temperature, and relative humidity ranges presented in Table E-1. Prior to use in conditions outside these ranges or in any radio frequency (RF)/magnetic field, instruments shall be source checked to determine if their response is accurate. Following is the source check procedure:

- Contact the ES&H Team health and safety technician for an appropriate check source and instructions for its use.
- Source-check the instrument in the environment it is to be used before and after the radiation survey.
- Contact the ES&H Team health physicist if the instrument does not measure the check source accurately. Correction factors (e.g., air density for ion chambers), special adjustments (e.g., high-voltage reduction), or selection of a different instrument may be necessary.

Table E-1. Environmental boundaries for radiation detectors.

Detector type	Temp (°F)	Relative humidity (%)	RF/ magnetic field	Pressure	Comments/Cautions
G-M	50 to 110	10 to 80	Test required	Sea level to 10,000 ft	—
Scintillation	50 to 90	10 to 80	Test required	Sea level to 5,000 ft	—
Ionization chamber	50 to 90	10 to 80	Test required	Sea level to 10,000 ft (Air density corrections are likely needed at >2,000 ft)	Eberline models RO-2, RO-2A, and RSO-5 may read zero in strong magnetic fields. Certain instruments (e.g., Victoreen 471RF) have some protection against RF fields, but they should also be source checked.
Air or gas flow proportional	50 to 90	10 to 80	Test required	Sea level to 1,500 ft	Failures have been noted above 90% relative humidity; high voltage shall be reduced to operate at high elevations

Appendix F

Radiological Records Retention

Records that are generated as a result of the Rule's requirements shall be retained until DOE authorizes their disposition. This appendix identifies the individuals and organizations responsible for various records. It also provides guidance for the long-term retention of these records.

Table F-1 lists the types of records that should be retained and the individual or organization responsible for doing so. Responsibility typically lies with the individual or organization that produced the record. However, where there is a distributed responsibility for a record, the involved organizations (e.g., the program, facility, or service organization) should jointly determine who will be responsible for the record and clearly document the decision.

Note: The records in Table F-1 may not be generated in all facilities.

The responsible individual or organization shall

- Maintain custody of the identified records or send them to long-term storage in accordance with the Storage Retrieval Disposition Guidelines available from Records Storage.
- Ensure one-of-a-kind documents (e.g., ALARA records, field-swipe records, ES&H Team health and safety technician logbooks) can be located. It is important to document the location of infrequently collected records to ensure they are not lost in the event of personnel or program changes.
- Produce records when requested (e.g., for audits and inspections).
- Protect records from damage.
- After accumulating a sufficient quantity of frequently generated records (e.g., surveys, Equipment Release Forms, swipe surveys), sort them by record type and arrange them in chronological order.

Table F-1. Radiological records retention list.

Type of record	Responsible individual or organization ¹
Policy Statements (and revisions)	
Document 20.1, "Occupational Radiation Protection," in the <i>ES&H Manual</i> and its associated documents	ES&H IMO
Policies	HC-RSS
Implementing procedures (and revisions)	
Master Health Physics Discipline Action Plan (HP-DAP)	HC-RSS
<i>Radiation Safety Sign Manual</i>	HC-RSS
<i>Swipe Manual</i>	HC-RSS
Safety Plans	
Integration Work Sheets	Program or HC ES&H Team
Facility safety plans (and revisions)	Program or HC ES&H Team
Operational safety plans (and revisions)	Program or HC ES&H Team
Radiological and/or Hazardous Work Permits	Program or HC ES&H Team
Hazard Assessments (Radiological)	Program or HC ES&H Team
Individual Records	
Dosimetry records for anyone monitored with an LLNL dosimeter	HC-RSS
Records of doses received during emergency conditions, accidents, and planned special exposures	HC-RSS
Medical evaluations and treatment performed in support of the radiological protection program	Health Services Department
Records of declarations of pregnancy and retractions	HC-RSS
Medical restrictions (for radiological work)	Health Services Department
Records of medical approvals and fit-test results for respirator use	HC-CBSS
Individual course completion records	LTMO (LTRAIN)
Internal Dosimetry Program	
Technical basis document	HC-RSS
Policies	HC-RSS
Procedures (bioassay, calibration, and counting laboratory)	HC-RSS
Results of whole body counts and lung counts	HC-RSS

¹ HC = Hazards Control Department; ES&H IMO = ES&H Information Management Office; RSS = Radiation Safety Section; CBSS = Chemical and Biological Safety Section., SETS = Safety, Education, and Training Section

Table F-1. Radiological records retention list. (cont'd.)

Type of record	Responsible individual or organization ¹
Results of applicable urine, fecal, and specimen analysis results	HC-RSS
Records of dose assessments, if required	HC-RSS
Records of bioassay programs (participants)	HC-RSS
QA records	HC-RSS
Accountability records for sealed radioactive sources, and reports of loss of radioactive material	Materials Management
Radiological training course documentation	HC-SETS
External Dosimetry Program	
Technical basis document	HC-RSS
Policies	HC-RSS
Procedures	HC-RSS
Dosimetry results and dose reconstructions	HC-RSS
QA records (DOELAP audits)	HC-RSS
Results of maintenance and calibration performed on devices used for individual monitoring (dosimeters and personal alarming dosimeters)	HC-RSS
ALARA Records	
ALARA goals	Program or facility
Facility design reviews affecting radiological operations	Program or facility
Radiological safety analysis and evaluation reports	Program or facility
Plan and review of first time or infrequently conducted operations, including dose estimates or time motion studies [if not in an OSP, FSP, or radiation work permit (RWP)]	Program or facility
Internal Audits	
Internal audits and inspections and other reviews of radiological protection program content and implementations	HC-RSS/program/facility
Radiological Instrumentation	
Testing	HC-RSS
Maintenance	HC-RSS
Calibration records	HC-RSS
Operational logs (e.g., CAM logbooks)	HC-ES&H Team
Field Monitoring Records	
Discipline Action Plans (and revisions)	HC ES&H Team
Exposure surveys	HC-ES&H Team
Contamination surveys	HC-ES&H Team
<i>Swipe Manual</i> Logs	HC-ES&H Team
RGD survey records	RGD operator/safety officer

Table F-1. Radiological records retention list. (cont'd.)

Type of record	Responsible individual or organization ¹
Equipment Release Forms CAM alarm worksheets (for filters counted in the field) ES&H Team health and safety technician logbooks Air monitoring results	HC-ES&H Team or program HC-ES&H Team HC-ES&H Team HC-RSS
Radiological incident and occurrence reports (and critique reports, if applicable)	Program or facility